OAK PESTS

A Guide to Major Insects, Diseases, Air Pollution and Chemical Injury

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OAK PESTS: A Guide to Major Insects, Diseases, Air Pollution and Chemical Injury

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TABLE OF CONTENTS

INTRODUCTION

The oaks (*Quercus* spp.) are among our most valuable hardwood resources, amounting to one-third of the hardwood sawtimber volume in the United States. Over half the annual cut of oak lumber is produced in the 13 Southern States. Oaks are best known for their timber production and resulting fine furniture, beautiful flooring, and other products. Yet, aesthetics, watershed management, recreation, and wildlife are goals now given equal or greater priority by many. The oaks are valued for shade and ornamental purposes — a single tree sometimes adds thousands of dollars to real estate values.

Insects, diseases, and pollutants present a continuing threat to oaks. A major portion of the acorn crop is destroyed during some years — hampering regeneration efforts. Seedling mortality and dieback add to this problem. Terminal and top injury adversely affect tree form. Repeated defoliations cause growth loss and mortality. Borers and decay cause defect and degrade amounting to an annual loss of millions of dollars. Indirect losses occur through disruption of sustained forestry practices, regulation of forest types, and altered wildlife habitat. Homeowners may incur the expense of chemical control and possibly the cost of tree removal if mortality occurs. Nuisances created by numerous insects decrease tourist use and revenue.

It is far better to prevent attack by insects and disease than it is to remedy them after they occur. Be aware of, and use, cultural practices that maintain and promote tree vigor. Match tree species to the proper site. Assure sufficient water, nutrients, space, and sunlight. Avoid accidental injuries such as cuts, bruises, and broken limbs. Use practices that favor natural controls such as birds and other predators, parasites, and insect pathogens. Practices such as "pick-up and destroy" and "prune-out and destroy" can help reduce hibernating forms and inoculum reservoirs. When all else fails, chemical controls may become necessary.

This booklet will help nurserymen, forest woodland managers, pest control operators, and homeowners to identify and control pest problems on oaks. The major insect and disease pests of oaks in the South are emphasized. Descriptions and illustrations of the pests and their damage are provided to aid in identification. Brief notes are given on biology and control to aid in predicting damage and making control decisions. A list of chemical controls is provided. Chemical controls are subject to change as certain compounds are banned and new materials approved. Thus, the chemical control section can be removed (tear sheet) and discarded when outdated. For further information on pesticides, contact your State Forester, county agent, or the nearest office of State and Private Forestry, USDA Forest Service.

INSECTS

INSECT DEFOLIATORS

ELM SPANWORM, *Ennomos subsignarius* (Hübner)

Importance. — Elm spanworms attack red and white oaks, and other species especially *Carya,* (hickory, pecan and related trees) throughout the East. This is a destructive forest pest, particularly in the southern Appalachians where widespread, severe outbreaks have occurred. Repeated defoliation can cause growth loss, dieback, reduction in mast crops, and mortality.

Identifying the Insect (figure 1a). — Larvae are slate grey to brownish-black with yellowish body markings (yellow or green at low population densities) and 1.6 to 2 inches (40 to 50 mm) long. The adults are snow-white moths. The olive green eggs are laid in masses on the underside of small branches (figure 1b).

Identifying the Injury (figure 1c). — Young larvae feed on the edge and undersides of leaves, causing a shot hole appearance. Later, they consume the entire leaf except the main veins, leaving a feathered appearance to the tree.

Biology. — Overwintering eggs hatch in early spring when the buds break, usually April in the South. The larvae feed for 4 to 6 weeks, and then pupate in net-like cocoons on the host tree or understory. Six to 10 days later, in late June to mid-July, the moths emerge and deposit their eggs. There is one generation per year.

Control. — Insect parasites attack the eggs of the elm spanworm. Other natural enemies also are important in keeping infestations in check. Chemical controls are often needed to protect high-value trees.

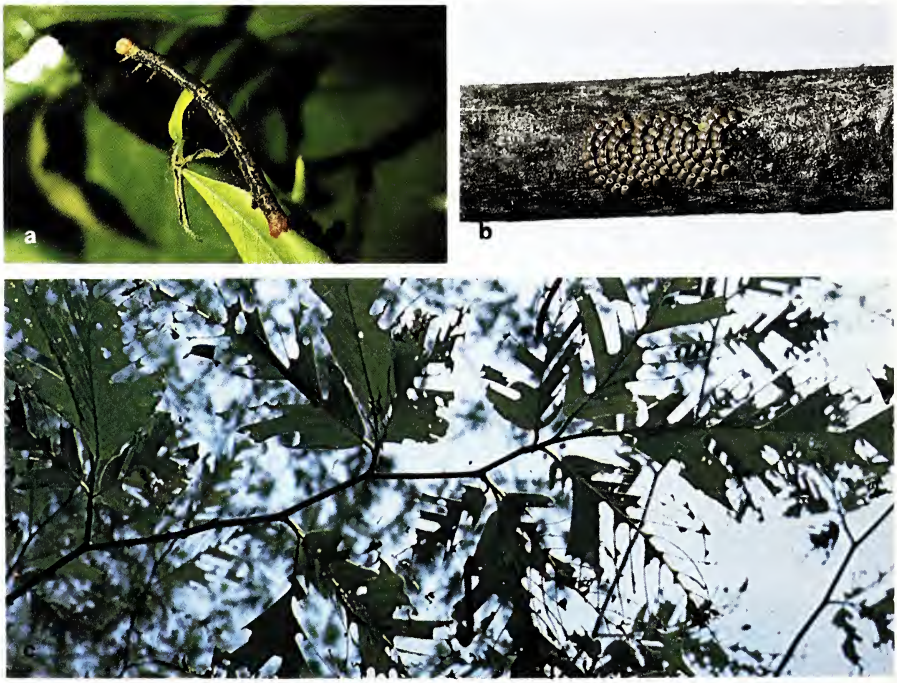


Figure 1. — (a) Elm spanworm larva; (b) elm spanworm egg mass on branch; (c) defoliation by elm spanworm.

FALL CANKERWORM, *Alsophila pometaria* (Harris)

Importance. — The fall cankerworm is one of the most common and injurious species of loopers in eastern forests. Repeated defoliation causes growth loss, reduction in mast, can eventually kill trees and causes a nuisance in high-use areas.

Identifying the Insect (figure 2a). — Larva color varies with population density from light green with yellow stripes, to green with a dark dorsal stripe, to black with whitish lines. The mature larva is .8 to 1-inch (19 to 25 mm) long. The adult female is wingless and ash gray; males have wings. Eggs are laid in masses of more than 100 on small twigs (figure 2b).

Identifying the Injury (figure 2c). — Early signs are small holes in leaves or complete skeletonization of the leaves. Larger larvae consume all except the midrib and major veins. Feeding is complete in 5 to 6 weeks.

Biology. — Overwintering eggs hatch in late April or early May. The larvae feed on young leaves at branch tips. Mature larvae enter the soil to pupate. Adults emerge, mate, and deposit eggs in November and December. There is one generation per year.

Control. — The eggs and larvae of the fall cankerworm are attacked by insect parasites. Other natural enemies also help control this pest. Sticky bands placed on trunks of high-value trees can snare the wingless females before they lay their eggs. Chemical controls may be needed.

Figure 2. — (a) Fall cankerworm larva; (b) fall cankerworm female moth and egg mass on branch; (c) oak stand defoliated by fall cankerworm.

ORANGESTRIPED OAKWORM, *Anisota senatoria* (J. E. Smith)

Importance. — This defoliator occurs over much of the East. It defoliates trees in parks, campgrounds, picnic areas, and along city streets. However, forest stands of red and white oaks on upland sites suffer most when outbreaks occur.

Identifying the Insect (figure 3a). — The larva is black with eight narrow yellow stripes; it is about 2 inches (50 mm) long. There is a pair of long, curved "horns" on the second thoracic segment. The adult moth is yellowish-red; forewings are orange-purple and each has an oblique band and white spot.

Identifying the Injury (figure 3b). — Young larvae feed in groups, skeletonizing the leaf. Later, they consume all but the main veins. Older larvae are less gregarious and can be found crawling on lawns and sides of houses.

Biology. — Adults appear in June and July, and deposit clusters of several hundred eggs on the underside of leaves. The eggs hatch within a few days and the caterpillars feed during July to September for 5 to 6 weeks. In the fall, mature larvae pupate in the soil, where they overwinter. There is generally one generation per year.

Control. — Natural enemies generally prevent widespread defoliation, but chemical control may be needed for high-value trees.

Figure 3. — (a) Orangestriped oakworm larva; (b) tree defoliated by orangestriped oakworm.

VARIABLE OAKLEAF CATERPILLAR, *Heterocampa manteo* (Doubleday)

Importance. — This defoliator is common throughout eastern North America. It feeds on all species of oaks, but prefers the white oaks. Some infestations have covered millions of acres — retarding growth and tree vigor. Outbreaks usually subside after 2 to 3 years, before serious tree mortality occurs.

Identifying the Insect (figure 4a). — Caterpillar color is variable, but is generally yellowish green with a narrow white stripe down the center of the back, bordered dorsally with reddish-brown, and one or two yellowish stripes on the sides. Mature larvae may reach 1.5 inches (37 mm) long. The adult moth is ashy grey with three dark wavy lines across the forewings.

Identifying the Injury (figure 4b). — Young larvae skeletonize the leaf while older larvae devour the entire leaf except the leaf stalks and main veins. There are two periods of defoliation — one in June to July and another in August to October.

Biology. — There are two generations in the South and one generation in the North. In the South, the larvae feed from early May until late June, and pupate in the soil. Second-generation larvae feed from mid-August until late September, then move to the ground to spin cocoons and overwinter as prepupae. Larvae of the single generation in the North are present during June to mid-August.

Control. — Insect parasites and predators eat the eggs and larvae of this pest. Winter mortality also helps keep most infestations in check. Chemical control is occasionally needed to protect high-value trees.

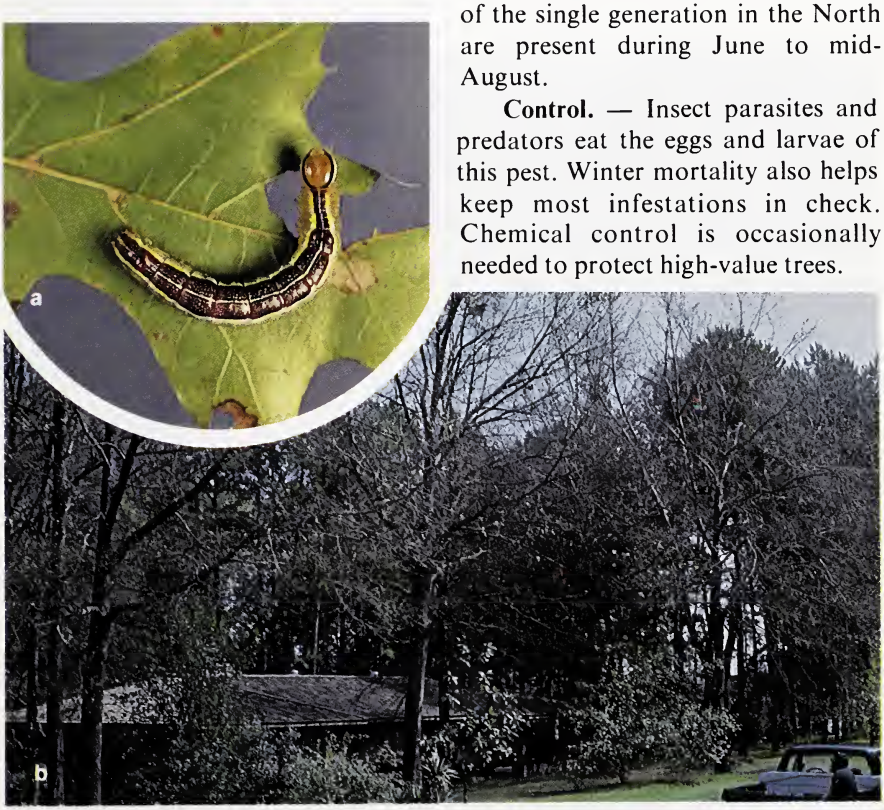


Figure 4. — (a) variable oakleaf caterpillar larva; (b) defoliation by variable oakleaf caterpillar in residential area.

YELLOWNECKED CATERPILLAR, *Datana ministra* (Drury)

Importance. — This caterpillar is a defoliator of oaks and a few other hardwoods throughout the United States. Infestations have been most common in the Appalachian and Ozark Mountains and foothills. Damage is more severe to shade and ornamental trees than to forest stands.

Identifying the Insect (figure 5). — The larva is yellowish and black striped, and moderately covered with fine, white hairs. The head is jet black; the segment behind the head is bright orange-yellow — hence its name, yellownecked caterpillar. Full grown larvae are about 2 inches (50 mm) long. When disturbed, the larvae lift their head and tail in a distinctive "U" shape.

Identifying the Injury. — Newly hatched larvae skeletonize the leaf; older larvae devour all except the leaf stalk. Individual trees, or even stands, may be defoliated during summer and early fall.

Biology. — Moths appear during June and July and deposit white eggs in masses of 50 to 100 on the undersides of the leaves. Larvae feed in groups, maturing in August and September. Mature larvae drop to the soil and pupate at depths of 2 to 4 inches (5 to 10 cm) where they spend the winter. There is one generation per year.

Control. — Natural enemies generally keep infestations in check. Chemical controls are occasionally needed.

Figure 5. — Yellownecked caterpillar larvae.

FOREST TENT CATERPILLAR, *Malacosoma disstria* (Hubner)

Importance. — Outbreaks occur periodically on oaks and other hardwoods over wide areas of the eastern half of North America. Growth loss and dieback occur, but trees are seldom killed unless they sustain 3 or more successive years of defoliation.

Identifying the Insect (figure 6a). — Caterpillars have pale bluish lines along the sides of a brownish body; a row of keyhole-shaped white spots down the middle of the black back; sparsely covered with whitish hairs; and reach 2 inches (50 mm) at maturity. Adult moths are buff-brown with darker, oblique bands. Egg masses of 100 to 350 eggs encircle the twigs and are covered with frothy, dark brown cement.

Identifying the Injury (figure 6b). — The first noticeable signs of attack are sparse crowns and falling frass. Caterpillars often cluster on the lower trunks of infested trees. Trees or even stands may be completely defoliated during spring.

Biology. — Eggs hatch in early spring. Caterpillars feed for 4 to 6 weeks on the opening buds, foliage, and flowers. Despite its name, this species does not form tents. Pupation occurs in yellowish cocoons and lasts 10 to 14 days. Moths emerge from late May to July and deposit their eggs, which overwinter. There is one generation per year.

Control. — Natural controls include insect parasites of the pest's eggs, larvae, and pupae. Predators, virus and fungus diseases as well as high and low temperatures also kill forest tent caterpillars. Several chemicals and a microbial insecticide are registered for control.

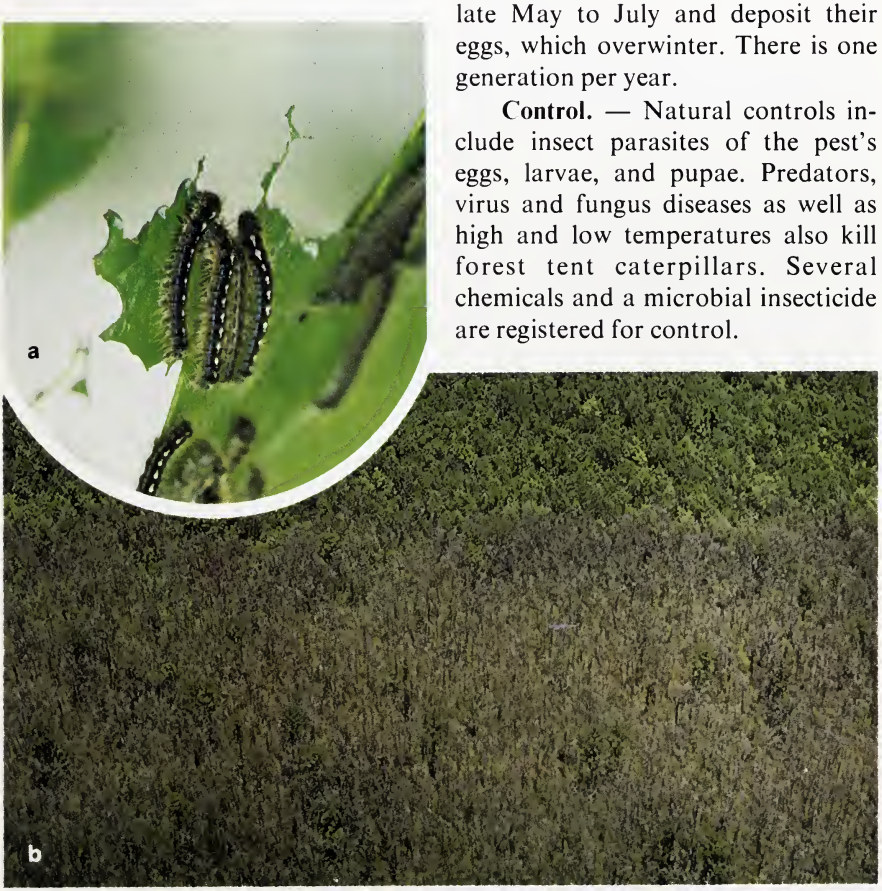


Figure 6. — (a) Forest tent caterpillar larvae; (b) defoliation by forest tent caterpillar.

GYPSY MOTH, *Lymantria dispar* (Linnaeus)

Importance. — The gypsy moth, which came from France, has long been considered one of the most important pests of red and white oaks in the Northeast. It has spread southward to Virginia and appears to be moving in on southern hardwoods. It causes widespread defoliation resulting in reduced growth, loss of vigor, mortality, and reduces aesthetic, recreational and wildlife values.

Identifying the Insect (figure 7a). — Larvae are brownish gray with tufts of hair on each segment and a double row of five pairs of blue spots, followed by six pairs of red spots, on the dorsum. Larvae are about 1.6 to 2.4 inches (40 to 60 mm) long. Adult females are whitish and males are dark brown.

Identifying the Injury (figure 7b). — Young larvae chew small holes in leaves. Older larvae feed on leaf edges, consuming entire leaves except for the larger veins and the midrib. The entire tree may be defoliated.

Biology. — Larvae emerge in May from overwintering eggs and feed until mid-June or early July. Pupation occurs in sheltered places and lasts 2 weeks. Adults emerge in July and August. Females deposit masses of 100 to 800 eggs covered with buff-colored hairs on trunks and other sites.

Control. — Natural controls including introduced insect parasites and predators, virus disease, and adverse weather conditions help control the gypsy moth. Chemical and microbial insecticides have been used extensively.

Figure 7. — (a) Gypsy moth larva; (b) defoliation by gypsy moth.

SLUG OAK SAWFLY, *Caliroa quercuscoccineae* (Dyar)

Importance. — This pest is usually endemic on the oaks; however, during 1974-1976, it was epidemic in Kentucky, Virginia and Tennessee. Repeated defoliations retard growth, vigor, and mast crops, and kill some trees.

Identifying the Insect (figure 8a). — Larvae are slug-like, yellowish-green and shiny with a black head and thoracic legs, and .5 inch (12 mm) long. Larvae feed in groups. The adult is a typical sawfly, about .25 inch (6-8 mm) long, and light brown.

Identifying the Injury (figure 8b). — Leaves may be skeletonized. Larvae consume the epidermis, making the leaf transparent. The leaf is left with a fine network of veins. Defoliation starts in the upper crown in early summer and progresses downward. By late summer, heavily infested trees may be completely defoliated.

Biology. — Larvae in cocoons survive the winter. Larvae pupate in the spring. Adults and larvae are present throughout the summer. Eggs are deposited in single rows of slits on the lower leaf surface along main veins. There are two to three generations per year.

Control. — Microbial diseases and other natural enemies generally keep the slug oak sawfly in check. Insecticides may be needed on high-value trees.

Figure 8. — (a) Slug oak sawfly larvae; (b) feeding injury by slug oak sawfly.

WALKINGSTICK, *Diapheromera femorata* (Say)

Importance. — The walkingstick attacks oaks and other species throughout the East. Branches are killed or die back in heavily defoliated stands. Continued defoliation for several years can kill the trees. The insects create a nuisance in high-use areas such as parks and recreation areas.

Identifying the Insect (figure 9a). — Nymphs and adults are slender and have long thin legs and antennae. While motionless, they closely resemble twigs of their host. Adults are about 2.5 to 3 inches (62-76 mm) long. Body color varies.

Identifying the Injury (figure 9b). — The entire leaf blade, except the base of stout veins, is consumed. During heavy outbreaks, large stands are often completely denuded. Trees may be defoliated twice during the same season.

Biology. — Overwintering occurs in the egg stage, in leaf litter. Eggs hatch in May and June. Nymphs reach adulthood during summer and fall. Females deposit up to 150 eggs which are dropped randomly to the forest floor. There is one generation per year in the South; 2 years are required farther North.

Control. — Natural controls are often effective. Chemical control is occasionally needed in high-use areas.

Figure 9. — (a) Walkingstick adult; (b) forest stand defoliated by walkingsticks.

OAK LEAFROLLER, *Archips semiferanus* (Walker)

Importance. — This insect sometimes defoliates many red and white oaks throughout the East. Defoliation has been most severe along ridge tops where white and chestnut oak frequently occur. Forest areas are often defoliated for several consecutive years, killing many trees.

Identifying the Insect (figure 10). — Larvae are various shades of green about 1.2 inch (29 mm) long, and have black heads. At rest, the wings of the adult appear bell-shaped and are creamy brown and gray with a darker cross band.

Identifying the Injury. — The larvae either fold or roll individual leaves together, forming an enclosure for protection and rest, when not feeding. Extensive stands of trees may be completely defoliated, including the understory.

Biology. — Overwintering eggs hatch in April and the young larvae begin rolling the leaves and feeding. Feeding is complete by mid-June and pupation occurs in cocoons within the rolled leaf or in bark crevices. Moths emerge in late June or early July and deposit eggs in masses on the trunk and branches.

Control. — Natural enemies are usually effective. Chemical controls may be needed to protect high-value trees.

Figure 10. — Oak leafroller larvae.

SOLITARY OAK LEAFMINER, *Cameraria hamadryadella* (Clemens)

GREGARIOUS OAK LEAFMINER, *Cameraria Cincinnatiella* (Chambers)

Importance. — These leafminers occur over much of the East. They attack various oaks, but prefer the white oak group. Heavy infestations cause browning and premature dropping of foliage — sometimes over large areas.

Identifying the Insect. — Adults and larvae of both species are similar. Young larvae are flat and taper toward the rear, and are about .25 inch (6 mm) long at maturity. Adults are pale and silvery with bronze patches on the wings.

Identifying the Injury. — Larvae of the solitary oak leafminer feed singly, forming irregular, blotch-like mines just below the upper leaf surface; a single leaf may contain several contiguous mines (figure 11). Larvae of the gregarious oak leafminer feed together, forming large mines.

Biology. — The winter is spent in the larval stage in leaves on the ground. Adult moths emerge during the spring and females lay eggs on the leaves. There are two to several generations per year.

Control. — Rake fallen leaves promptly and burn them to destroy pupae in cocoons. Natural enemies are helpful. Chemical control is occasionally needed.

Figure 11. — Leafmines caused by the solitary oak leafminer.

OAK SKELETONIZER, *Bucculatrix ainsliella* (Murteldt)

Importance. — This insect is common on the oaks, particularly the red oaks, in the East. Trees that sustain repeated attacks are weakened and suffer crown thinning and die-back. Ornamental trees appear especially vulnerable.

Identifying the Insect (figure 12a). — Larvae are slender, yellowish-green, and .2 inch (5 mm) long. They often spin down on silken threads when disturbed. Adults are small, blackish and marked with paler areas.

Identifying the Injury. — Caterpillars eat the fleshy green part of the lower surface, entirely or in part, which gives the leaves a brownish, skeletonized appearance (figure 12b). As heavily infested trees are defoliated, the skeletonized leaves drop off and cover the ground.

Biology. — Winter is spent in the pupal stage in white cocoons, about .1 inch (3 mm) long and ridged longitudinally on leaves and trunks. Adults emerge during the spring and deposit eggs on the undersides of fully grown leaves. The youngest (first-instar) larvae enter the leaves to feed, forming tiny mines. Older larvae feed externally. There are two or more generations per year.

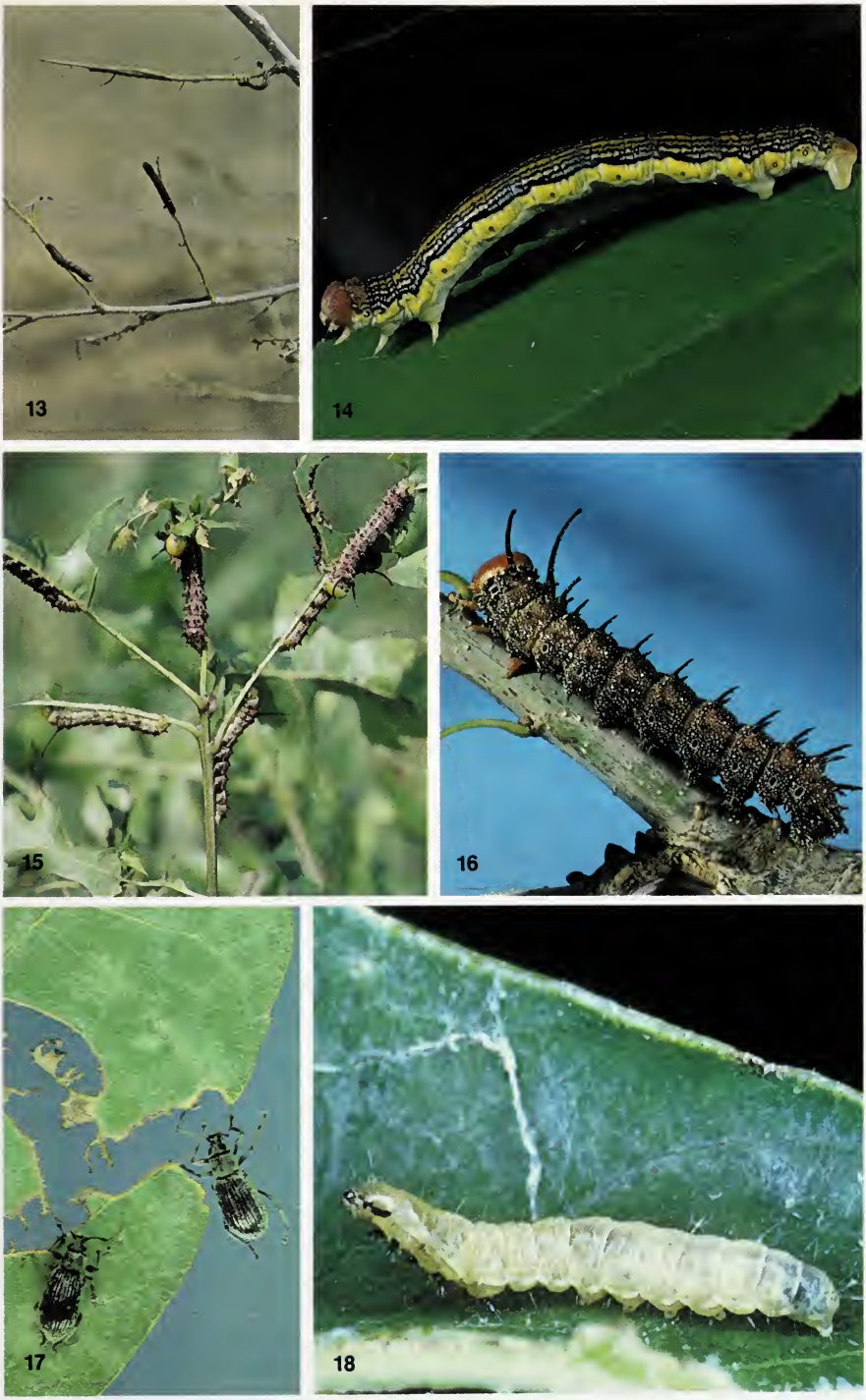
Control. — Rake fallen leaves promptly and burn them to destroy cocoons. Insecticides may be necessary on high-value trees.

Figure 12. — (a) Larvae and cocoons of oak skeletonizer on undersurface of leaf; (b) leaf skeletonized by oak skeletonizer.

MINOR DEFOLIATORS

Insect	Injury	Control*
Spring cankerworm, *Paleacrita vernata* (Peck); the larva (figure 13) is a typical looper, yellowish-brown to greenish-black with two yellowish stripes, about 1.2 inch (30 mm) long; the female moth is wingless, gray with black dorsal line; one generation per year.	Many hosts, heavy on live oak in Texas; skeletonizes leaves at branch tips; may devour all but midribs and large veins; outbreaks can occur on shade trees and forested areas; reduces tree vigor and growth.	1 2 11 12
Linden looper, *Erannis tiliaria* (Harris); the larva (figure 14) is a looper-type, yellow with brown head and 10 wavy black lines on dorsum,1.5 inches (37 mm) long; female moth is wingless, yellowish-gray with two rows of black spots; one generation per year.	Many hosts, heavy on white oaks in South; partial feeding on individual leaves (ragging) is typical, complete defoliation occurs during outbreaks; outbreaks less common in South than in North; reduces tree vigor and growth.	1 2 11
Pinkstriped oakworm, *Anisota virginiensis* (Drury); the larva (figure 15) is greenish-brown with four pink stripes, a pair of long, curved "horns" is on the second thoracic segment, 2 inches (50 mm) long; the adult is a brownish-red moth, white spot on forewings; two generations per year.	Red and white oaks; leaves eaten except leaf stalks and midribs; stripped branches and trees common, entire stands less common; defoliation in summer and fall; less common than orangestriped oakworm, except in bottomland forests; causes growth loss and crown decline.	1 11
Spiny oakworm, *Anisota stigma* (Fabricius); the larva (figure 16) is tawny and pinkish with white specks, 2 inches (50 mm) long, two long curved "horns" are on the second thoracic segment, and short spines on all other segments; one or two generations per year.	Red and white oaks; larvae feed on leaves, July to September, consuming all but leaf stalk and main veins; partial defoliation common; heavy widespread defoliation uncommon.	1 11
Asiatic oak weevil, *Cyrtepistomus castaneus* (Roelofs); adults (figure 17) are greenish-brown to black weevils, .25 inch (6 mm) long, with short snouts; one generation per year.	Wide host range, including red and white oaks; adults emerge in spring and feed on leaves by chewing in from the margins toward the midribs and devour all but the larger veins; during fall they create nuisances by invading houses in large numbers.	1 11
Oak leaftier, *Croesia semipurpurana* (Kearfott); the larva (figure 18) is dirty white to light green, .5 inch (12 mm) long, pale head, brownish thoracic legs; adults are yellow with brown markings; one generation per year.	Foliage of red oak group; young larvae feed on buds in early spring; older larvae fold or tie together sections of leaves with webbing and feed inside the folds until late May; severe outbreaks have occurred in upland oaks, killing some trees, with decline of others.	1 11

*See CONTROLS, page 66.



Figures 13-18. — (13) Spring cankerworm larvae on defoliated branch; (14) linden looper larva; (15) pinkstriped oakworm larvae; (16) spiny oakworm larva; (17) asiatic oak weevil and feeding injury; (18) oak leaftier larva.

INSECT BORERS

CARPENTERWORM, *Prionoxystus robiniae* (Peck)

Importance. — Carpenterworms are serious borers throughout the United States. Wormholes cause degrade estimated at 15 percent of the value of rough sawn lumber and unsightly scars on ornamental trees.

Identifying the Insect (figure 19a). — Newly hatched larvae are .25 inch (6 mm) long and reddish pink. Larvae gradually become greenish white and are 2 to 3 inches (50 to 75 mm) long at maturity. Brown pupal skins protruding from entrance holes are common in early summer. Adults are grayish, stout-bodied moths; the hindwing in the male has an orange spot (figure 19b).

Identifying the Injury (figure 19c). — Earliest signs of attack are sap spots on the trunk. Later, frass (wood chips and pellets) is ejected from entrance holes. Burrows 2 inches (50 mm) in diameter under the bark, and galleries .5 inch (12 mm) in diameter and 5 to 8 inches (12 to 22 cm) long in the wood are typical. Galleries are open or only loosely plugged with frass. Holes in lumber are dark stained.

Biology. — Adult moths appear in April to June and deposit 400 to 800 eggs in bark crevices. Eggs hatch in 10 to 12 days and young larvae tunnel into the bark and wood. Pupation occurs within the gallery during spring and lasts 3 weeks. A life cycle requires 1 to 2 years in the South, and 2 to 4 years in the North.

Control. — Maintain high tree vigor. Remove brood trees. Prevent bark injuries. Natural enemies help. Control with trunk spray or gallery fumigation.

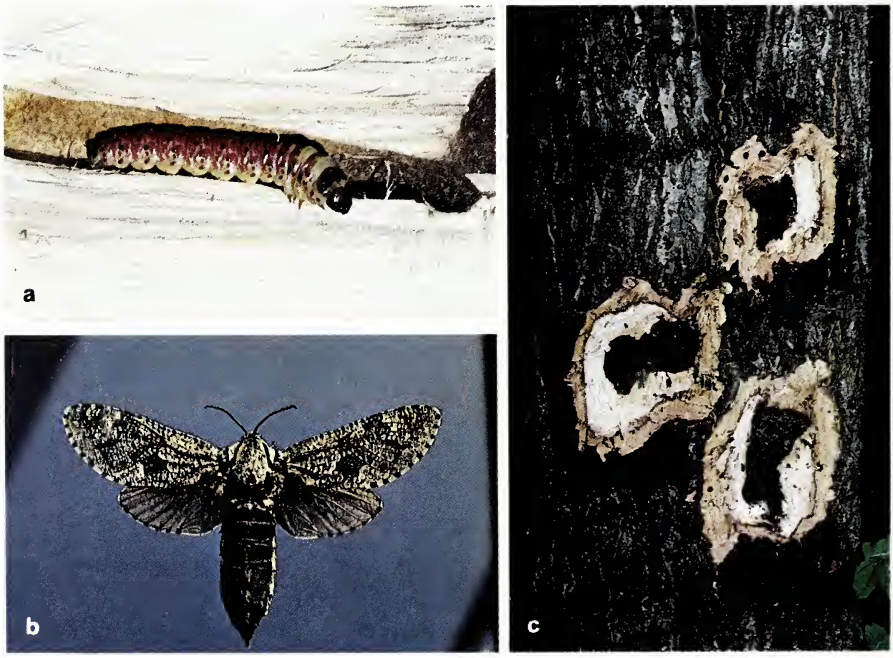


Figure 19. — (a) carpenterworm larva in gallery; (b) carpenterworm female moth; (c) tree trunk with carpenterworm attacks.

OAK CLEARWING BORER, *Paranthrene simulans* (Grote)

Importance. — This borer attacks the lower trunk of red and white oaks throughout the East. In the South, attacks are most common between root flanges of large red oaks. Damage includes degrade, entries for decay and nursery cull.

Identifying the Insect (figure 20a). — The larva is purplish gray, black head, brown thoracic shield, and 1 inch (25 mm) long. Adults are colorful, black and orange banded, beelike moths with a wing expanse of 1.5 inches (37 mm).

Identifying the Injury (figure 20b). — Sap spots and fine frass first appear. Later, granular frass is ejected in clumps from .3 to .6 inch (9 to 15 mm) entrance holes. There is little mining under the bark. Galleries are .3 inch (9 mm) in diameter, 4 inches (10 cm) long in the wood, and shaped much like those made by carpenterworms (figure 20c).

Biology. — Moths emerge during June and July and deposit eggs in bark crevices. Eggs hatch in 15 to 18 days and the larvae tunnel into the bark and wood of host trees. Pupation occurs within the gallery. A generation requires 2 years.

Control. — Open-grown trees are most susceptible, thus maintain a well stocked stand. Identify and remove brood trees. Prevent or minimize injuries. Larvae can be "wormed-out" with a knife and wire. Insecticides will protect valuable trees. Individual borers can be killed by gallery fumigation.

Figure 20. — (a) Male moth of oak clearwing borer; (b) oak clearwing borer entrance holes in bark; (c) gallery made by oak clearwing borer.

RED OAK BORER, *Enaphalodes rufulus* (Haldeman)

Importance. — Many of the large oaks in the East have been attacked by this borer, resulting in defects and serious degrade in the timber. Valuable shade trees in parks and cities are sometimes injured.

Identifying the Insect (figure 21a). — Adult borers, are light brown, robust beetles with long antennae and about 1 inch (25 mm) long. The shiny white, robust larvae have tiny legs on the thorax.

Identifying the Injury. — Initially, tiny pin-holes with fine, extruded frass are present. Later, entrance holes become larger and sap-stained, followed by ejection of granular frass (figure 21b). A few excelsior-like fibers are present in frass just before pupation. Tunnels are about .5 inch (12 mm) in diameter and 6 to 10 inches (15 to 25 cm) long (figure 21c).

Biology. — The pest has a 2-year life cycle. Eggs are laid in July and August on the bark. The larva mines under the bark during the first year, tunneling into the wood the second year. Pupation occurs and the adult exits through the bark near the entrance.

Control. — Maintain high tree vigor. Remove brood trees. "Worm-out" with knife or wire. Control in high-value trees with trunk spray or gallery fumigation.

Figure 21. — (a) Adult beetle of red oak borer; (b) sapstained bark and entrances typical of the red oak borer; (c) cross-section of oak trunk with red oak borer holes.

WHITE OAK BORER, *Goes tigrinus* (DeGeer)

Importance. — This borer is found in the East wherever its host species grow. Young trees 2 to 8 inches (5 to 20 cm) in diameter, in the white oak group are attacked. Some degrade occurs.

Identifying the Insect (figure 22a). — The larva is moderately robust and cylindrical; 1 to 1.5 inches (25 to 37 mm) long; yellowish-white; head strongly depressed with dark brown mandibles; and legless. The adult beetle has a spine on each side of the thorax; about .8 to 1 inch (20 to 28 mm) long; white and brown mottled; and antennae about as long as the body.

Identifying the Injury (figure 22b). — Egg niches .25 inch (6 mm) in diameter cut singly in the bark are followed by sap ooze and fine, moist frass. Later, the insects eject yellowish, ribbon-like pieces of frass containing pulverized wood and fibrous shreds. Galleries are about .5 inch (12 mm) in diameter and 6 inches (15 cm) long. Each borer leaves a small, elongate entrance hole and a circular .3 inch (8 mm) exit hole.

Biology. — Adult beetles emerge during May to June and deposit eggs. Eggs hatch in about 3 weeks and the larvae tunnel directly into the wood. Pupation occurs within the gallery and lasts 2 to 3 weeks. A life cycle requires 3 to 5 years.

Control. — Woodpeckers and sap-ooze are the most important natural controls. Remove brood trees. Follow practices that promote stand vigor. Direct controls are occasionally needed.

Figure 22. — (a) White oak borer larva in gallery; (b) brood-tree of white oak borer with numerous attacks and frass around the base of the tree.

TWOLINED CHESTNUT BORER, *Agrilus bilineatus* (Weber)

Importance. — This borer attacks red and white oaks throughout the East. Trees weakened by drought, defoliation, or other factors are most susceptible. Larvae destroy the cambium and girdle the tree. Mortality has been extensive in weakened stands.

Identifying the Insect. — Adult beetles are about .2 to .5 inch (6 to 12 mm) long, slender, and black with a light yellowish stripe on each wing cover. Larvae are white, slender, flattened, about 1 inch (25 mm) long, and have two spines at the rear end.

Identifying the Injury (figure 23). — Larvae excavate winding mines in the inner bark and outer sapwood of the main trunk and large branches, frequently girdling the tree. Attacks usually begin in the tree tops and extend downward as the trees continue to weaken. D-shaped emergence holes are evidence of infestation.

Biology. — Adults emerge during spring and early summer and deposit eggs in bark crevices. Eggs hatch in 10 to 14 days and the larvae burrow through the bark and cambium. They overwinter in cells in the bark and pupate the following spring. There is one generation per year.

Control. — Control is mainly a matter of preventing attacks through cultural practices that promote tree vigor. Spraying to protect foliage from defoliators is recommended in some areas. Trunk sprays offer some promise.

Figure 23. — Twolined chestnut borer larvae and mines in inner bark.

OAK TIMBERWORM, *Arrhenodes minutus* (Drury)

Importance. — The oak timberworm is a major cause of defect and degrade in the red and white oaks in the East. Attacks are most commonly associated with wounds on mature trees.

Identifying the Insect (figure 24a). — Adults are brownish black, brentid weevils about 1 to 1.4 inches (25 to 35 mm) long. The female has a narrow snout, while the male's mouth-parts are broad and flattened. The larvae are white, elongate, cylindrical, and curved (figure 24b).

Identifying the Injury. — Attacks usually occur at blazes, around other borer entrances, and other wounds that expose the sapwood. White, powdery frass at egg sites on exposed wood is good evidence of infestation. Winding tunnels .1 inch or smaller (0.2 to 3 mm) in diameter, characterize damage in lumber.

Biology. — During spring and early summer, females chew cylindrical holes into the sapwood and lay single eggs. Eggs hatch in a few days and the larvae bore almost through the tree then "U-turn" back across the grain to the point of origin. Pupation occurs in the gallery, and adults emerge through circular holes near the egg site. The life cycle requires 2 to 3 years.

Control. — Avoid wounds and injuries, including other borer attacks to largely prevent infestation by the oak timberworm.

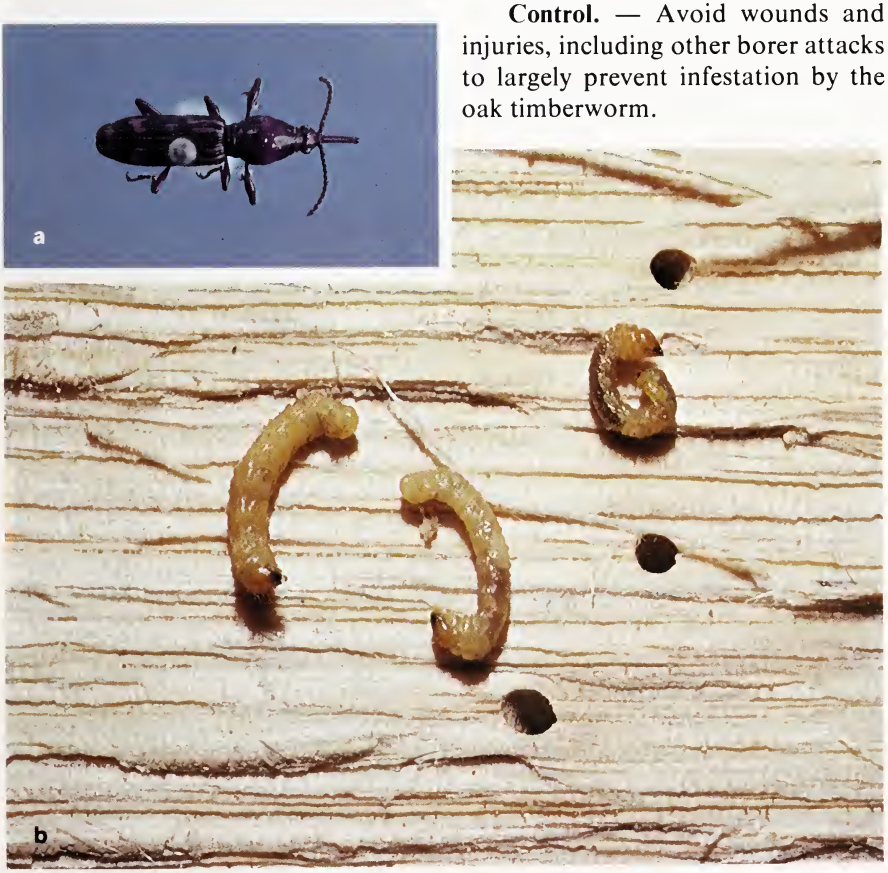


Figure 24. — (a) Oak timberworm adult female; (b) oak timberworm larvae and galleries in wood.

COLUMBIAN TIMBER BEETLE, *Corthylus columbianus* (Hopkins)

Importance. — This beetle occurs over much of the East and attacks the white oaks and, to a lesser extent, the red oaks. It attacks the trunks of live trees of all sizes. Damaged wood is degraded for such uses as veneer, cooperage, and furniture.

Identifying the Insect (figure 25a). — Adults are black to reddish-brown, cylindrical beetles about .2 inch (4 mm) long. The larvae are white, legless and C-shaped.

Identifying the Injury (figure 25b). — Holes less than .1 inch (1 to 2 mm) in diameter, are bored straight into the sapwood until the tunnel nears the heartwood, then it turns right or left. Damage is conspicuous in log ends. Streaks of stain originating from the tunnels are known as flagworm defects.

Biology. — Adult beetles construct galleries. Eggs are laid in chambers along the main tunnel where the larvae live and develop. Larval food is a white fungus that grows on the gallery walls. There are two to three generations per year.

Control. — There is no apparent relationship between tree vigor and susceptibility. No natural enemies have been found. Protection of veneer-quality trees with insecticides seems possible.

Figure 25. — (a) Columbian timber beetle adult in brood cell; (b) columbian timber beetle galleries and "flag" stains in white oak.

PIN-HOLE BORERS, *Platypus spp.* and *Xyleborus* spp.

Importance. — These ambrosia beetles are best known for their damage to fresh-cut logs and unseasoned lumber. They also readily attack weakened, stressed, and dying trees and healthy trees with bark injuries. Damage is largely in the form of degrade.

Identifying the Insect. — Adult beetles are black to brown; .1 to .2 inch (3 to 6 mm); elongate and cylindrical with a wide head in *Platypus* and cylindrically compact in *Xyleborus* species. Larvae are white, slightly curved to curculiform, legless, and .1 to .2 inch (3 to 6 mm) long.

Identifying the Injury (figure 26a). — White to light brown boring dust in small piles in bark crevices is good evidence of attack. Numerous round holes about .1 inch or less (1.5 to 3 mm) in diameter, branched or unbranched, stained black, extend into the wood. The lower trunk may sustain hundreds of attacks (figure 26b).

Biology. — The beetles are attracted to wood with a moisture content above 48 percent. They do not feed on the wood, but instead feed upon ambrosia fungi which they culture within the galleries. In the Gulf States, beetles are active most of the year. There are two or more generations per year.

Control. — Maintain tree vigor. Salvage infested timber immediately. Promptly use logs during summer months. Store logs under water or water spray. Green lumber is often kiln dried or chemically dipped to prevent attack.

Figure 26. — (a) Pin-hole borer attacks indicated by frass on bark; (b) numerous holes made in wood by pin-hole borers.

TWIG PRUNER, *Elaphidionoides villosus* (Fabricius)

Importance. — The twig pruner occurs throughout the East. It prefers the oaks but also attacks other deciduous species. Larvae bore into the stems and cut off or prune twigs, terminals, and branches about .25 to 1 inch (6 to 25 mm) in diameter. Severe pruning adversely affects tree form and the aesthetic quality of ornamental plantings, and creates clean-up problems.

Identifying the Insect (figure 27a). — Larvae are cylindrical, white, and measure about .5 to .8 inch (12 to 21 mm) long at maturity. Adult beetles are gray mottled.

Identifying the Injury (figure 27b). — During the summer, fall, and winter, pruned twigs (with leaves attached) 12 to 40 inches (30 to 100 cm) long litter the ground under infested trees. The end of the severed twig presents a smoothly cut surface. Split the pruned twigs to reveal the larva.

Biology. — Adults emerge during spring and deposit eggs in small twigs. The larva burrows down the center of the stem and severs the twig, which falls to the ground, in late summer or fall. Pupation and adult emergence occur the following spring. There is one generation per year.

Control. — Collect and burn severed twigs during the fall and winter. Natural enemies help control the twig pruner. Insecticides are rarely needed.

Figure 27. — (a) Ends of girdled twigs, tunnel, and larva of twig pruner; (b) young tree with top recently severed by twig pruner.

TILEHORNED PRIONUS, *Prionus imbricornis* (Linnaeus)
BROADNECKED ROOT BORER, *Prionus laticollis* (Drury)

Importance. — These root borers occur throughout the East. Roots are often hollowed or severed. Open-grown trees and those weakened by disease are most susceptible. Young, vigorous trees are occasionally cut off at the ground.

Identifying the Insect (figure 28a). — Larvae of both species are fleshy, creamy white with three pairs of small legs. They have cylindrical bodies and attain lengths of up to 3 inches (75 mm). The adult beetles are robust, broad, dark brown, somewhat flattened, and up to 1.5 inches (37 mm) long (figure 28b).

Identifying the Injury. — Because injury occurs to the roots below ground, correct diagnosis is difficult. The above-ground symptoms are gradual decline of the tree, characteristic of severe, prolonged stress, i.e., leaves sparse, small, and yellowish. Examination of roots reveal the burrowing larvae and root damage (figure 28c).

Biology. — Adult beetles emerge from the soil in early summer and deposit 300 to 500 eggs in the soil. Young larvae burrow through the soil to the roots and begin feeding. The feeding period lasts 3 to 5 years.

Control. — Disease, drought, mechanical injury, and poor soil conditions increase tree susceptibility. Therefore, follow cultural practices that will keep trees thrifty and vigorous. Insecticides are seldom needed.

Figure 28. — (a) Larva of Prionus *species tunneling in root; (b) adult beetle of* Prionus *sp.; (c) root damage by* Prionus *sp.*

MINOR BORERS

Insect	Injury	Control*
Little carpenterworm, *Prionoxystus macmurtrei* (Guerin); larva (figure 29) pink to white, dark head and thoracic shield, 2.25 inches (57mm); adult gray-mottled moth; life cycle 2 to 3 years.	Trunks and branches of sawtimber and shade trees; prefers red oaks; mine under bark, and gallery in wood .4 x 6 inches (1 x 15 cm); frass of wood chips and excrement pellets; causes lumber degrade, disfigures ornamental trees.	5 7 8 9 11 13
Beech borer, *Goes pulverulentus* (Haldeman); roundheaded larva, white, legless, cylindrical, about 1.5 inches (37 mm); adult brownish-gray longhorned beetle; life cycle 3 to 5 years.	Trunks of saplings and poles of red oaks; attacks are clustered (figure 30); galleries are about .4 x 8 inches (0.9 x 20 cm); grayish frass with fibrous shreds extruded in ribbons; degrade, entries for decay, stem breakage.	1 5 6 7 * 11
Spotworm borer, *Agrilus acutipennis* (Mannerheim); larva is slender, flattened, white, about 1.3 inches (32 mm) long; adult beetle is narrow, dark metallic blue, about .5 inches (12 mm) long; a generation requires 2 years.	Trunks over .5 inch (12 mm) in diameter in white oak group, particularly heavy on overcup oak in river bottoms; larvae tunnel spirally in outermost growth ring (figure 31); spot stains and frass-packed tunnels are defects that degrade lumber.	5
Flatheaded appletree borer, *Chrysobothris femorata* (Olivier); larva (figure 32) is flatheaded, white, about 1 inch (25 mm) long; adult beetle is oval, flattened, greenish bronze, about .6 inch (16 mm) long; one generation per year.	Trunks and branches of red and white oaks of all sizes; larvae bore into phloem and outer sapwood; mines girdle and kill small trees; newly transplanted trees and those weakened or stressed are most susceptible.	5 8 9 10 11
Oak branch borer, *Goes debilis* (LeConte); roundheaded larva, legless, yellowish-white, about .6 inch (15 mm); adult longhorned beetle, mottled reddish-brown and gray; life cycle 3 to 4 years.	Small branches and terminals about .3 to 1.5 inches (9 to 37 mm) in diameter, mainly white oaks; attacks (figure 33) near crooks and branch crotches; galleries about .2 x 3 inches (6x75 mm); yellowish frass protrudes from elongate entrance hole; infested stems become swollen, and often break or die back.	1 3 5 6
Oak-stem borer, *Aneflormorpha subpubescens* (LeConte); roundheaded larva, slender, about .7 inch (18 mm) long; adult narrow, light brown, spine on the third and fourth segments of antennae. One generation per year.	Seedlings and sprouts about .5 to 1 inch (12 to 25 mm) diameter; red and white oaks; larva bores down center of stem, cutting off sections, burrows to stem base or roots to overwinter; frass is ejected through row of small holes in bark (figure 34), kills large numbers of seedlings and sprouts in Southeast.	1 11

*See CONTROLS page 66.

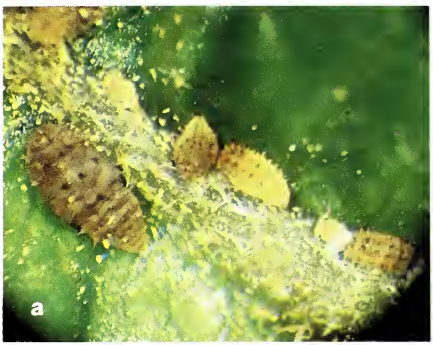
Figures 29-34. — (29) Little carpenterworm larva; (30) cluster of attacks on sapling by beech borer; (31) bark removed to expose larval mines of spotworm borer; (32) flatheaded appletree borer larva in mine under bark; (33) oak branch borer entrance, with yellow frass; (34) oak-stem borer larva in gallery of stem with row of small holes.

MISCELLANEOUS INSECTS

OAK PHYLLOXERIDS, *Phylloxera* spp.

Importance — Phylloxerids are very small, aphid-like insects that attack the foliage and buds of red and white oak trees of all sizes. Heavy infestations stunt and weaken the trees. The distorted foliage mars the beauty of ornamentals.

Identifying the Insect (figure 35a). — Phylloxerids are small .01 to .02 inch (0.3 to 0.6 mm) long, aphid-like, lack cornicles and usually spiny in appearance. Winged forms have reduced wing veination. They are usually found in clusters.



Identifying the Injury (figure 35b). — Buds and young developing leaves (undersurface) on terminals and branch ends are attacked, causing the leaves to curl and twist. Growth may be reduced or stopped. Mature and nearly mature leaves are unaffected. Damage occurs during spring and early summer.

Biology. — The biology is not well known, but overwintering occurs as eggs in bark crevices. Eggs hatch during the spring. There appear to be several generations per year.

Control. — Natural controls usually keep damage to a minimum. Ornamentals may require chemical control.

Figure 35. — (a) Close-up of oak phylloxerid feeding along leaf midrib; (b) left, leaves curled and deformed by phylloxerids; right, healthy leaves.

OAK LEAF APHIDS, *Myzocallis* spp.

Importance. — These aphids infest the undersides of leaves, leaf stalks, and tender twigs of trees in the red and white oak groups throughout the East. Heavy infestations distort the foliage and weaken the plants. Honeydew and sooty molds further mar the beauty of ornamentals.

Identifying the Insect (figure 36). — The aphids are .04 to .06 inch (1 to 1.5 mm) long, soft-bodied, pear-shaped, with a pair of cornicles at posterior of abdomen. They may be yellow, green, pink, or brown, with darker pigmented blotches on the abdomen, and dusky bands on wings. Winged and wingless forms occur.

Identifying the Injury. — Clusters of aphids feed largely on the underside of the leaves. Feeding injury curls and folds the leaves. Every leaf on a tree may be curled and distorted during heavy attacks. Leaf surfaces become sticky with honeydew followed by growth of black, sooty fungus.

Biology. — Overwintering occurs as eggs deposited in bark crevices of host plants. The eggs hatch in the spring and nymphs begin feeding on the leaves. There are several generations per year, but the highest populations have been observed during the spring.

Control. — Natural enemies usually keep infestations in check. Insecticides are sometimes needed on ornamentals and other high-value trees.

Figure 36. — Oak leaf aphids.

OAK LACE BUG, *Corythucha arcuata* (Say)

Importance. — Adults and nymphs feed on white oaks from Alabama and the Carolinas to southern Canada. By the end of August, the leaves may be discolored and perform little photosynthesis.

Identifying the Insect (figure 37). — Nymphs are black and covered with spines. Adults have broad, transparent, lacelike wing covers; flattened; and about .25 inch (6 mm) long.

Identifying the Injury. — Infested leaves have chlorotic flecks on the upper side of the leaf. Heavily infested trees may be partly defoliated, especially during dry weather.

Biology. — Adults overwinter in bark crevices and similar protected areas of their host. They arouse from hibernation during spring and attach eggs to the underside of leaves. Upon hatching, nymphs begin feeding on the underside of the leaf. A complete cycle from egg to adult may develop in 30 to 45 days; several generations occur each year. In late summer, all active stages may feed together.

Control. — Natural enemies are usually effective. Chemical controls may be needed on shade and ornamental trees.

Figure 37. — Adults and nymphs of oak lace bug.

PERIODICAL CICADA, *Magicicada septendecim* (Linnaeus)

Importance. — Cicadas (locusts) attack oaks as well as other species and are widely distributed in the East. Egg-laying punctures by the adults often severely damage young, transplanted trees and branches of large trees.

Identifying the Insect (figure 38a). — Adults are heavy bodied, and 1.6 inches (40 mm) long. Their wings are transparent with prominent veins. The female is completely black on top, while the male has four or five orange-brown abdominal segments.

Identifying the Injury (figure 38b). — Females puncture the twig in straight rows to lay eggs and often damage twigs so severely that their terminal portions die. Large numbers of molted skins of the nymphs may be found attached to trees trunks.

Biology. — The adult female cuts the bark of twigs and lays 24 to 28 eggs. Newly hatched nymphs drop to the ground, burrow into the soil, and feed on the roots for 13 to 17 years.

Control. — Protect small trees with netting. Properly timed insecticides may be necessary.

Figure 38. — (a) Periodical cicada; (b) branches with egg-laying puncture injuries by periodical cicada.

LECANIUM SCALES, *Lecanium* spp.

Importance. — The lecanium scales are distributed throughout the United States. High scale populations severely reduce vitality, weaken the tree, and cause branch or crown dieback. They have been of greatest concern to shade and ornamental red and white oaks.

Identifying the Insect (figure 39). — The body of the adult female is circular to ovoid, strongly convex or tortoise-shaped, and about .2 to .3 inch (4 to 7 mm) in diameter. Young females may be tan or mottled with black, but older females are reddish or dark brown. After their eggs hatch, the female body shells remain loosely attached to the bark. Scales commonly overlap and encircle portions of infested twigs.

Identifying the Injury. — Trees of poor vigor or with branch and crown dieback should be examined closely for scale insects. Lecanium scales are most prominent on twigs during the spring and early summer.

Biology. — Eggs are produced underneath the female in late spring. Eggs hatch in early summer and the immature insects seek feeding sites on the underside of leaves. In late summer, they migrate to twigs where they overwinter. They complete their development in the spring. There is usually one generation per year.

Control. — Parasites and predators are effective in controlling infestations. However, insecticides are often used and are most effective against immature scales.

Figure 39. — (a) Lecanium scale insects on a branch.

GOUTY OAK GALL, *Callirhytis punctata* (Osten Sacken)

Importance. — This gall is among over 600 gall insects that attack the oaks in the United States. Gouty oak gall is most common on scarlet, red, pin, water, and black oaks. In heavy infestations, twigs, large branches, and occasionally entire trees may be killed.

Identifying the Insect. — Adults are small, black, cynip wasps with an oval, shiny, and slightly compressed abdomen. The larvae are white and globe-shaped.

Identifying the Injury (figure 40a). — Galls are irregular, globose, woody, 1.5 inches (38 mm) in diameter, and encircle the twigs and small branches. They sometimes occur so close together that they form nearly continuous masses (figure 40b).

Biology. — This species has alternate generations. The first produces small blisterlike galls on leaves in the spring. The second produces gouty galls during the summer.

Control. — Natural controls are generally adequate. Prune galls from small trees and destroy. Chemical control is possible, but poorly defined.

Figure 40. — (a) Close-up of single gall showing gall insect emergence holes; (b)trees heavily infested by gouty oak galls.

OAK-APPLE GALL, *Amphibolips confluenta* (Harris)

Importance. — This is one of many leaf galls that affect oaks. These galls usually damage the tree less than do twig galls. However, heavy infestations of this and other leaf galls can cause premature leaf fall and are unsightly on ornamental trees.

Identifying the Insect. — Adults are very small and dark with an oval, compressed abdomen. The larvae are small and globe-shaped.

Identifying the Injury (figure 41). — Galls are about .5 to 2 inches (12 to 50 mm) in diameter, and are filled with a fibrous mass. Each contains a single larva inside a hard center capsule. The galls are produced on the midrib or stem of leaves. Galls formed during spring are green, but become light brown on drying with a thin, papery shell. Oak-apple galls occur principally on red, black, and scarlet oaks.

Biology. — Oak-apple galls usually start during spring when the young leaf is being formed, sometimes appropriating the entire leaf for its own purpose. The biology is poorly known, but it probably has alternate generations on different host parts.

Control. — Natural enemies are usually sufficient. Galls can be picked or pruned off small ornamental trees. Direct controls are seldom necessary.

Figure 41. — Cluster of oak-apple galls.

ACORN WEEVILS, *Curculio* spp.

Importance. — These weevils attack both red and white oaks and are found wherever the hosts grow. Also, weevils in the genus *Conotrachelus* and moths in the genus *Melissopus* account for some losses. A major portion of the crop may be destroyed.

Identifying the Insect (figure 42a). — Acorn weevils are robust and brown. The beak is long and slender, sometimes longer than the body, in the female. The larvae are legless, robust, dirty-white, and C-shaped.

Identifying the Injury (figure 42b). — There may be one or more holes in the acorn. Dissecting the acorn will reveal signs of feeding and one or more C-shaped larvae.

Biology. — Female weevils drill one or more holes into the acorn and deposit a single egg in each hole. Larvae feed until full grown, then cut exit holes in the shell. Full-grown larvae enter the soil where they spend 1 to 2 years before pupating and emerging as adults.

Control. — Natural controls help to minimize losses. Chemical control may be needed in seed orchards.

Figure 42. — (a) Adult acorn weevil on acorn; (b) larva, feeding injury, and exit hole of acorn weevil.

MINOR MISCELLANEOUS INSECTS

Insect	Injury	Control*
Giant bark aphid, *Longistigma caryae* (Harris); (figure 43) with relation to other aphids, this species is very large, .25 inch (6 mm) long, long slender legs, and is covered with a bluish-white "bloom"; several generations per year.	Terminals, twigs, and branches of red and white oaks; aphids feed by sucking the plant sap; heavily infested stems badly weakened or killed; honeydew and sooty molds mar beauty of ornamentals.	1 11
Pit scales, *Asterolecanium* spp.; adult females are circular and enclosed in yellowish, waxy, translucent covering, .04 to .08 inch (1 to 2 mm) in diameter; one generation per year.	Found on twigs, branches, and trunks of red and white oaks; prefers white oaks; maturing females produce ring-like swellings or pits on the bark (figure 44) causing a rough appearance; branches and trees may be killed.	1 11
Kermes scales, *Kermes* spp.; adult females are globular or gall-like, yellow-brown-black, solid or mottled, about .1 to .3 inch (3 to 7 mm) in diameter.	Scales (figure 45) occur on twigs, branches, near buds, near wounds, on leaf midribs, and petioles of red and white oaks; dieback or "flagging" of newly formed terminals, branch ends, and new leaves; early leaf drop; mar beauty of shade trees.	1 11
Obscure scale, *Melanaspis obscura* (Comstock); adult female cover (figure 46) circular, grayish to black — resembling bark in color .08 to .1 inch (2 to 3 mm) in diameter; two generations per year.	Trunks and branches of red and white oaks; infestations are often heavy and layered, killing branches, or resulting in general weakening, and sometimes death of tree.	1 11
Spider mites, *Oligonychus* spp. and *Eotetranychus* spp.; .02 inch (0.5 mm) long, spider-like, eight legs, sucking mouthparts; large numbers often present; many generations per year.	Foliage and buds of red and white oaks; scattered chlorotic stippling on leaves (figure 47) later yellowing or bronzing, then browning and dying of foliage; mats of webbing often present; weakens tree and mars beauty.	1 11
White grubs, *Phyllophaga* spp.; larva (figure 48) is milky white, C-shaped, about 1 inch (25 mm) long, brown head; adult beetle is robust, oval, brown, about .5 to 1 inch (12 to 25 mm) long.	Wide host range, including oak seedlings and young trees; larval feeding prunes and girdles roots; nurseries and young plantations often damaged; adults may defoliate trees.	1 11

*See CONTROLS page 66.

Figures 43-48. — (43) Nymphs and adults of giant bark aphid; (44) pit scale on oak branch; (45) kermes scale on oak twigs; (46) obscure scale on oak branch; (47) left, healthy leaves; right, chlorotic stipling caused by spider mites; (48) left, white grubs and root injury; right, healthy roots.

DISEASES

DECAY FUNGI – CANKER ROTS

HISPIDUS CANKER, *Polyporus hispidus* (Bull.) Fr.

Importance — Hispidus canker, caused by *P. hispidus,* appears on willow oak, Nuttall oak, white oak, and hickory. Incidence of infestation varies by area and species, but may be as high as 13 percent. Cankers lengthen about 6 inches (15 cm) yearly. The decay column length exceeds the canker length. Diseased trees are quickly converted to culls.

Identifying the Fungus (figure 49a).— Hispidus conks are about 2 to 12 inches (5 to 30 cm) wide, spongy, stalkless, yellowish-brown to red, with pores on the lower surface. Conks are produced during the summer or fall. They dry to a black mass, fall, and can usually be found around the base of infected trees.

Identifying the Injury (figure 49b). — Hispidus cankers are large, elongate, sunken in the center and bordered by callus folds. Infected stems become spindle-shaped. A small branch stub may be found near the center where the infection started.

Biology. — Microscopic spores are released from conks for a few weeks. They are spread by the wind, but most travel no more than 140 yards (128 m). Spores reaching dead branches on healthy trees start new infections. Conks will form after deadening or felling diseased trees.

Control — Cut hispidus-diseased trees as soon as possible for salvage and to reduce disease spread by limiting spore dissemination to healthy trees. No suitable treatment is known for high-value trees in urban areas.

Figure 49. — (a) Polyporus hispidus *conk; (b) Hispidus canker.*

SPICULOSA CANKER, *Poria spiculosa* Campb. & Davids

Importance. — Spiculosa cankers, caused by *P. spiculosa,* may occur on up to 10 percent of the bottom-land red oaks in some areas. The decay column increases about 10 inches (25 cm) in length, yearly.

Identifying the Fungus. — Conks of *P. spiculosa* develop flat under the bark and the brown fruiting surface becomes exposed with maturity following tree death. Doubtful infections can be identified by chopping into the canker center. The brown fungus material will be exposed if the infection is well established.

Identifying the Injury (figure 50). — Cankers appear as rough, circular swellings with depressed centers. Remains of a branch stub can usually be found in the center of the canker.

Biology. — Spores are released from the conks and carried by the wind to branch stubs on healthy trees where infection occurs. Trees respond to invasion of the cambium by developing callous tissue.

Control. — Cut diseased trees or deaden them to allow room for healthy growing stock. No suitable treatment is known for high-value trees in urban areas.

Figure 50. — Spiculosa canker, including cross section.

IRPEX CANKER, *Irpex mollis* Leys ex Fr.

Importance. — Irpex canker, caused by *I. mollis,* occurs most frequently on red oaks. Incidence of this disease varies greatly in different areas. It is the least common of the canker rots, affecting only a small percentage of the trees. However, the decay under Irpex cankers extends above and below the canker face as much as 8 feet (2.4 m). The rate of decay is unknown.

Identifying the Fungus (figure 51). — The conks of *I. mollis* are 1 to 5 inches (2.5 to 12 cm) wide and creamy white, yellowing with age. They have short, jagged "teeth" on the lower surface. Conks usually occur during late summer and fall.

Identifying the Injury. — Infections are associated with dead branch stubs. Irregular cankers up to 2 feet (0.6 m) long may develop. There is white rot in the heartwood behind these cankers. The canker face will have a number of sunken areas with swollen margins resulting from callous tissue formation.

Biology. — Reproduction is by means of microscopic spores, produced and released by the conks each fall. The spores are spread by the wind to branch stubs on susceptible trees where infection occurs. The wood is decayed and the cambium killed, causing progressively larger cankers.

Control. — Control measures are similar to those described for hispidus cankers.

Figure 51. — Irpex mollis *conks on canker surface, including cross section.*

BUTT ROTS

Importance. — Butt rot, the decay at the base of living trees, is the result of the invasion of one of a number of decay fungi (*Polyporus* spp., *Hericium* sp., and *Pleurotus* sp.) which enter the trees through wounds. Fire wounds are the most typical type. Data indicate that butt rot affects 29 percent of the white oaks and 39 percent of the red oaks on loess and alluvial sites in the Midsouth. It is the most serious cause of cull.

Identifying the Fungi. — Numerous fungi can cause butt rot; however, five are responsible for about one-half of the identified cases. The following description will help to identify the most common fungi.

Hedgehog Fungus Rot. — *Hericium erinaceus* (Bull.) Pers conks are 4 to 10 inches (10 to 25 cm), globular, and occur singly or in clusters. They are white, but yellow with age, and have tooth-like projections pointing downward. This fungus is found mostly during the fall in butt hollows or where other openings in the tree have developed (figure 52).

Polyporus Fungus Rot. — *Polyporus fissilis* Berk & Curt., produces shelf-like, white, succulent conks 3 to 8 inches (7.6 to 20.3 cm) wide, that yellow with age (figure 53). The lower surface is made up of small pores. They usually appear during the fall or winter.

Figure 52. — Hericium erinaceus *conk.*

Figure 53. — Polyporus fissilis *conk.*

Varnish Fungus Rot. — *Polyporus lucidus* Leys ex. Fr. produces conks 3 to 10 inches (7.6 to 25. 4 cm) in size and which appear yearly during the summer, usually near the soil line (figure 54). The conks have a shiny, reddish, hard upper surface; a short, stout stalk; and pores on the lower surface. The consistency is tough and woody.

Sulfur Fungus Rot. — *Polyporus sulphureus* Bull. ex Fries has conks 2 to 12 inches (5 to 30 cm) wide. They are soft, fleshy, moist, bright orange-red on the upper surface and red-yellow on the lower pore surface. The conks become hard, brittle, and white with age. They appear singularly or in clusters, usually during the fall (figure 55).

Oyster Fungus Rot. — *Pleurotus sapidus* Kalchr. forms shelf-like conks which are white to light grey. They are soft and fleshy and may have a short stalk. Gill structures radiate from the point of attachment on the lower surface (figure 56). Conks appear on living trees and slash during most of the year except dry periods.

Identifying the Injury (figure 57). — Conks, old wounds, hollows, abnormal swellings or butt bulge indicate butt rot. Decayed wood may be soft or brittle, and brown to white. The decay core may be small or include the entire heartwood. The core extends vertically from less than an inch to several feet. Affected trees are weak and subject to breakage.

Figure 54. — Polyporus lucidus *conk.*

Figure 55. — Polyporus sulphureus *conk.*

Biology. — Following tree wounding, bacteria and non-decay fungi flourish on the exposed woody tissues, creating conditions for establishment of decay fungi. Windborne microscopic spores released for a few days to several weeks from conks on infected trees germinate on wounds and penetrate the tree. The decaying stage of the rot fungi follows and conks will be produced. The rate of decay varies with the tree species, fungus, and wound size. Decay is most extensive when wounds are large; decay usually does not develop in wounds less than 2 inches (5 cm) wide. Regardless of wound size, wood volume loss is minimal when wounds are less than 4 years old.

Control. — Because all infections occur through bark wounds, injury prevention is the primary approach to control. Severely decayed trees of no value should be deadened. Consider early salvage for infected trees that have value because the lower, most valuable portion of the log is being decayed, with an increased susceptibility to insect attack, windthrow and degrade from stain. Repair valuable urban trees by removing the decay, treating the cavity with a fungicide and filling it with a suitable material.

Figure 56. — Pleurotus sapidus *conk.*

Figure 57. — Butt bulge indicates decay.

TOP ROTS

Importance.— Top rot results from the invasion of the heartwood by many of the same fungi *(Sterium spp. and Poria* sp.) which cause butt rot. The incidence of infection is similar to butt rot, but typically less. However, the associated volume losses are much less since this disease occurs in that part of the tree which is not usually used for timber. Top rot results in limb breakage and thus becomes important as a safety hazard in high use and urban areas.

Identifying the Fungi. — Three common top rot fungi, *S. gausapatum* Fr., *P. andersoni* (E11 & Ev) Neuman and *S. subpileatum* Berk. & Curt. must usually be identified by cultural characteristics because conks rarely are seen on dead branches. Others, such as *Hericium erinaceus, Polyporus fissilis, Pleurotus sapidus* and *Polyporus sulphureus* were described previously with butt rot fungi.

Identifying the Injury.— The presence of broken limbs often indicates decay (figure 58). Examination of the broken surface will confirm its existence. Presence of branch scars alone indicates top rot. The incidence and amount of decay rise sharply with increased size and/or age of scars. The decay can be estimated by judging the scar size and age in broad classes (table 1).

Table 1. Expected length of decay in the main stem behind branch scars of oaks.

	Diameter of branch scar		
	inches (cm)		
Age	1-3 (2.5-7.5)	4-6 (10.2-15.2)	7-10 (18-25)
less than 15 years	1.2 (3.0)	4.8 (12.1)	30 (76.2)
more than 15 years	2.4 (6.0)	12 (30.4)	68.4 (173.7)

Biology. — The life cycle of heart rot fungi, as top rots, is about the same as was discussed for butt rots. The environment differs, thus some different fungi are involved. Those butt rot fungi which invade the roots are not encountered and others, such as *Stereum* sp., become more prevalent.

Control. — There are no measures for direct control of top rots. Recognizing top decay and early harvesting of infected trees is the most useful control method. Prevention of injuries inflicted during logging could help reduce top rot in growing stock. In urban or high-use areas, early detection and appropriate removal of hazardous limbs should be carried out.

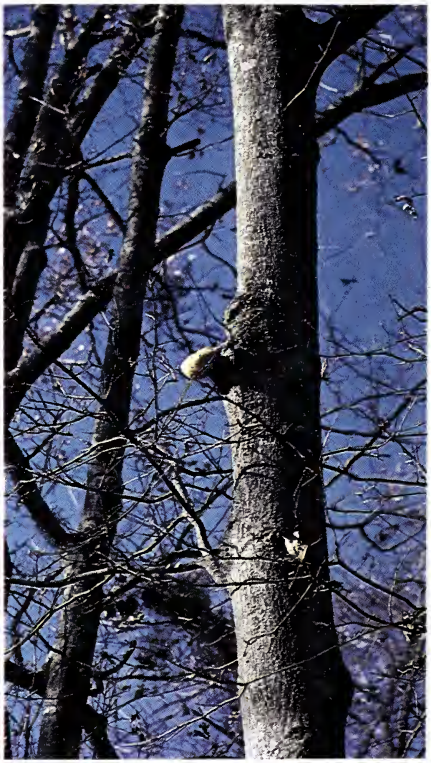


Figure 58. — Fungus conk indicates top rot.

ROOT ROTS

CORTICIUM ROOT ROT, *Corticium galactinum (Fr) Burt*

Importance. — The fungus causes root rot on many hardwoods and conifers in the United States. It has a wide host range and causes extensive damage to oaks growing on poor sites.

Identifying the Fungi. (figure 59). — The white mycelial mat covers the root crown and roots. It can be detected easily by removing the soil around the base of the tree. The fungus produces a very inconspicuous fruiting structure that can be seen only with the aid of a microscope.

Identifying the Injury. — Thin crowns are the first symptoms usually observed. Some suckering and undersized leaves may appear before the trees die. Trees may die in a growing season and retain leaves until the following year. Root damage can be observed by removing soil from around the root crown. Trees may be windthrown because of the root rot.

Biology. — The fungus can live as a saprophyte on roots and stumps. The spread is caused by infected roots in close association with living roots. Insects also disseminate the fungus to healthy trees.

Control. — In intensively managed plantations or in urban forestry, remove dead trees to reduce spread to adjacent trees. Rate of spread in soil is about 1 foot (0.35 m) per year.

Figure 59. — Mycelium of Corticium galactinum *on oak seedling.*

TEXAS ROOT ROT, *Phymatotrichum omnivorum* (Shear) Dug.

Importance. — *Phymatotrichum omnivorum* can cause root rot on many dicotyledonous plants in the Southwest. Oaks planted on old farm fields in reforestation projects or in subdivisions may become infected.

Identifying the Fungus. — During warm, wet periods, the spore mat may grow on the soil surface. Infected root surfaces are covered by a fluffy, yellowish mycelium which penetrates the cortex (figure 60). Microscopic examinations show distinct cross-shaped hyphae by which identification of the fungus can be made.

Identifying the Injury. — Diseased trees have a thin crown, top dieback and poor vigor. The disease is more readily detectable on young, newly established seedlings which may wilt and die suddenly.

Biology. — The fungus is soil-borne and persists in the soil as sclerotia for many years. Infection occurs when mycelial strands cover the root and enter between the epidermal cells. The spores produced on the mature mats rarely germinate and their function in the spread of the disease is uncertain.

Controls. — Use soil amendments to increase soil acidity. The fungus is not a serious pathogen in acid soils. The use of resistant plants, such as monocotyledons, is recommended in areas that have a history of the disease.

Figure 60. — Texas root rot of oak seedlings.

SHOESTRING ROOT ROT,
Clitocybe tabescens (Scop. ex Fr.) Bres,
Armillaria mellea Vahl ex Fr.

Importance. — Root rot organisms, *C. tabescens* and *A. mellea,* cause major losses throughout the United States. Windthrow of infected trees in urban and high-use areas contribute to the importance of root diseases. Additional losses occur from loss of vigor.

Identifying the Fungi (figure 61). — In the fall, clumps of yellow mushrooms grow on the ground near the tree and occasionally on the bole several feet above the ground. Thin black strands of mycelia (rhizomorphs) are produced on the root surface which resemble black shoe laces. *C. tabescens* is a southern form of *A. mellea.* The mushroom has decurrent gills and produces white spores.

Identifying the Injury. — Infected trees may have low vigor. Roots may show various degrees of decay and have rhizomorphs on the surface. Frequently, root rot is evident only on wind-thrown trees. The rate of spread in the soil is about 1 foot (0.35 m) per year.

Biology. — The fungus can live in dead roots and stumps for many years. Rhizomorphs spread through the soil on infected roots near healthy roots that become infected. Mushrooms produce abundant spores, but they are not important in infection of living trees. The fungus is most pathogenic on slow-growing trees.

Controls. — Spread can be controlled by removing the infected tree. Sterilize the soil before replanting. Any cultural practices that reduce stress and increase tree vigor will prolong tree life.

Figure 61. — Clitocybe tabescens *mushrooms on oak.*

WILTS

TEXAS LIVE OAK DECLINE,
Ceratocystis fagacearum (Bretz) Hunt

Importance. — "Live oak decline" is a major disease that kills thousands of high value live oaks annually in Texas. Live oaks in Louisiana, Mississippi, and Florida have shown symptoms similar to those observed in Texas.

Identifying the Fungus. — The primary pathogen, *C. fagacearum,* can be identified by isolating it from infected sapwood and through microscopic observation. Cultures are gray to tan and exhibit a fruity odor. Blunt, cylindrical microscopic spores are produced. Black, flask-shaped fruiting structures may develop.

Identifying the Injury. — The initial symptoms are chlorotic leaf mottling, leaf browning, and defoliation (figure 62a). Later, the tree develops small leaves, water sprouts, twig and limb dieback, and eventually the tree dies (figure 62b). Cankering fungi also cause dieback and death after trees are stressed by wilt.

Biology. — Live oak trees in Texas are infected by *C. fagacearum,* and develop initial symptoms mainly during the spring and fall. The fungus spreads through root grafts and by insect vectors. Dieback from canker fungi develops mainly during the summer months.

Control. — Control procedures are the same as for oak wilt.

Figure 62. — (a) Early symptoms of live oak decline; (b) advance symptoms of live oak decline.

OAK WILT, *Ceratocystis fagacearum* (Bretz) Hunt

Importance. — Oak wilt is the most destructive disease of oaks in the upper Mississippi Valley. Red oaks are affected more than the white. The disease can kill oaks rapidly and cause heavy losses.

Identifying the Fungus. — The fungus can be identified in the field by presence of fungal mats and pressure cushions under the bark of infected trees. Identification can also be made by observing the fungus microscopically (see "live oak decline").

Identifying the Injury. — Symptoms are bronzing or browning of green leaves from tips and margins downward toward the leaf base (figure 63a) defoliation, and eventually death (figure 63b). Defoliated leaves usually accumulate under affected trees. The red oaks develop symptoms over the entire crown shortly after infection, but white oaks slowly develop symptoms in a few limbs at a time.

Biology. — Oak wilt is favored by moderate temperatures. The fungus will not grow at high temperatures. It spreads for short distances through root grafts between infected and noninfected trees. Insects spread the disease over long distances.

Control. — Kill infected trees with silvicides to reduce inoculum and prevent root graft transmission.

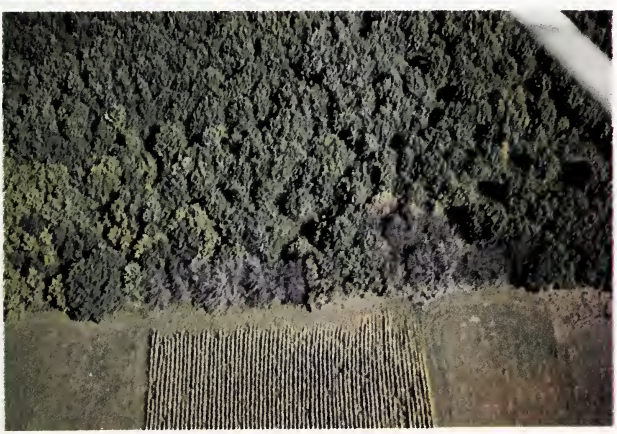


Figure 63. — (a) Foliar symptoms of oak wilt; (b) oak wilt symptoms in a natural stand.

CANKERS

NECTRIA CANKER, *Nectria galligena* Bres.

Importance. — Nectria cankers, caused by *N. galligena,* are frequently found on some oak species. These cankers are most important in trees less than 20 years old. The canker can girdle and kill young trees or make them weak and subject to wind breakage.

Identifying the Fungus. — The fungus can be identified by the creamy-white fruiting structures that appear on cankers soon after infection. It can also be identified by the small, red, lemon-shaped perithecia near canker margins after 1 year.

Identifying the Injury (figure 64). — Well-defined localized areas of bark, cambium, and underlying wood are killed by the invading fungus. A concentric callus ridge develops around the expanding canker annually and bark sloughs off the older parts of the canker. After several years, the annual concentric callus ridges on the cankers resemble a target.

Biology. — The fungus overwinters as a saprophyte in cankers and produces spores for new infections during the spring. Windblown and water-splashed spores infect tree wounds and branch stubs. Secondary infections result from spores produced on new spring cankers.

Control. — Cankers may be minimized in high-value areas by not pruning during wet weather, avoiding wounds, pruning out branch cankers, and sterilizing pruning tools before moving to an uninfected tree.

Figure 64. — Nectria canker.

BOTRYODIPLODIA CANKER, *Botryodiplodia theobromae* Pat.

Importance. — *B. theobromae,* can cause cankers and dieback in oak species over a wide geographical area. It is a potentially destructive pathogen under certain adverse environmental conditions, especially if trees are somewhat stressed.

Identifying the Fungus. — Black, stromatic fruiting structures of the fungus develop on bark over the cankers. However, microscopic examination of spores is necessary for correct identification. Mature spores are dark, two-celled, and elongate.

Identifying the Injury. — It is difficult to identify the canker by symptoms alone. Therefore, the fungus must be isolated and identified. Active cankers on trees with rough bark can be detected only after removing bark to expose dead cambium. Old or inactive cankers appear sunken and are surrounded by callus tissues. Dieback is frequently caused by *B. theobromae,* but can be confused with injury resulting from other diseases or stress conditions (figure 65).

Biology. — The biology of Botryodiplodia cankers in oaks is poorly known. However, the cankers are favored by high temperatures. Cankers and dieback can develop rapidly in stressed trees. Fungal spores are spread by the wind and insects.

Control. — Cankers can be minimized by preventing wounds, pruning out cankered and dead limbs to reduce inoculum, and maintaining tree vigor when possible.

Figure 65. — Botryodiplodia canker, including cross section.

HYPOXYLON CANKERS, *Hypoxylon* spp.

Importance. — Hypoxylon cankers affect most oak species in North America. Both *H. atropunctatum* and *H. mediterranium* have been reported in oaks. They affect mainly trees that have been stressed by wilt, drought, construction damage, or other injuries. Limbs and boles weakened by *Hypoxylon* spp. can be a safety hazard in high-use areas.

Identifying the Fungus (figure 66). — *Hypoxylon* spp. can be identified by the light-to-dark-colored crusty fungus tissue (stromata) over the cankered area. Numerous small black fruiting structures are embedded in the stromata.

Identifying the Injury. — Bark sloughing and decay are associated with Hypoxylon cankers. Affected trees are subject to wind breakage.

Biology. — The fungus infects stressed trees through wounds and either produces a canker or quickly kills the tree by colonizing the sapwood. Fruiting structures develop on the cankers and ascospores are discharged into the air and spread to new infection sites. Hypoxylon cankers are generally secondary to some other disease or stressing condition in trees.

Control. — Remove cankered limbs before they fall on someone, and to reduce the amount of inoculum for new infections. Maintain tree vigor and avoid wounding and stubbing of branches to minimize conditions favoring cankers.

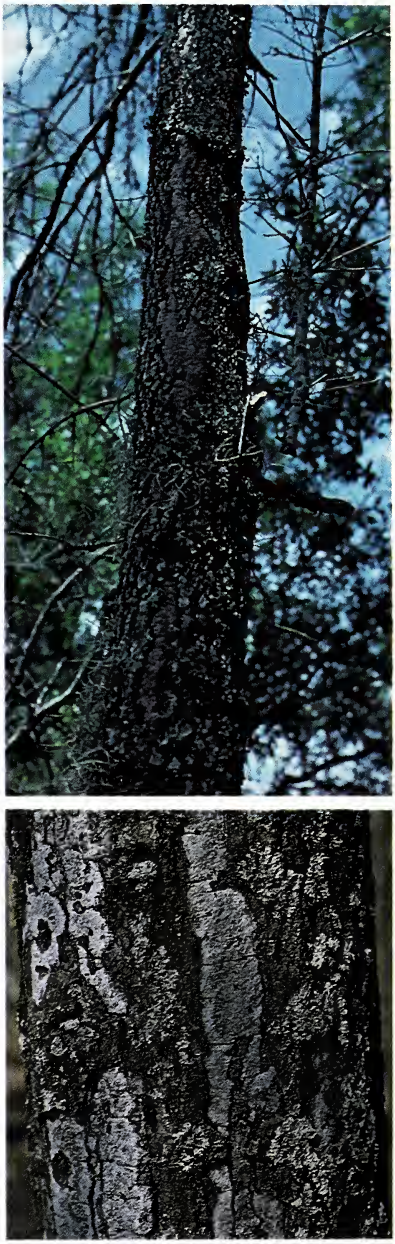


Figure 66. — Hypoxylon canker, including close-up view.

LEAF DISEASES

ANTHRACNOSE, *Gnomonia quercina* Kleb = *Gloeosporium quercinum* West

Importance. — Severely affected oaks may be defoliated by midsummer, which reduces growth, predisposes trees to other diseases and makes the trees unsightly. White oaks are most severely affected. Anthracnose does not result in major losses in forests.

Identifying the Fungus. — Black, dot-size, cushion-like, fruiting bodies form on necrotic tissue where spores are produced. A beaked, flask-shaped, fruiting structure can be found on overwinter leaves.

Identifying the Injury (figure 67). — Round to irregular, light-brown to black areas appear on the leaf most frequently along veins. Affected leaves often appear scorched, and may curl or twist and drop from the tree. Infrequently, cankers on small twigs and dieback can occur.

Biology. — The fungus overwinters in dead leaves. Spores (ascospores) are windblown to the new, expanding leaves and shoots. Another spore type (conidia), which reinfects other leaves or shoots, is then produced.

Control. — Collect and dispose of fallen leaves and twigs. Remove unneeded branches to increase air movement. Fertilize to increase vigor and use fungicide sprays.

Figure 67. — Oak anthracnose, including close-up view.

LEAF BLISTER, *Taphrina caerulescens* Tul.

Importance. — Because most of the affected leaves remain on the tree, oak leaf blisters do not cause losses under forest conditions. Affected trees may appear unsightly, but there is little damage.

Identifying the Fungus. — The mycelium occurs intercellularly in the leaf tissue. Dome-shaped, microscopic, fungus cells are formed beneath the cuticle, usually on the upper leaf surface. The distal cell becomes the sac (ascus) in which eight ascospores are formed.

Identifying the Injury (figure 68). — Affected leaves develop many blisters on the upper surface. The blisters are round, raised, wrinkled and vary in color from yellow to purple. The leaf is depressed on the corresponding lower surface.

Biology. — Spores (ascospores) of the fungus are produced on the surface of the blisters. The spores are carried by the wind to bud scales where they remain over winter. In the spring when the buds are expanding, the fungus enters the leaf through the natural leaf openings (stomata) and the cycle is complete.

Control. — Collect and dispose of leaves. Plant or manage for resistant oak such as pin and Shumard. Properly timed fungicide sprays can control this fungus.

Figure 68. — Oak leaf blister.

ACTINOPELTE LEAF SPOT, *Actinopelte dryina* (Sacc.) Hoehn.

Importance. — Actinopelte leaf spot can reach epidemic proportions and cause major loss of foliage. Growth losses, increased stress on the tree and unsightly conditions result. Overall, the disease normally remains endemic and causes foliage loss only in the fall, with no subsequent effect.

Identifying the Fungus. — Small, brown, dot-like fruiting bodies are formed on the necrotic tissue. Spores are elliptic and clear or colorless and can be microscopically observed by crushing a fruiting body.

Identifying the Injury (figure 69). — Round to irregular, red-brown spots develop along the leaf veins. The spots are normally surrounded by light brown areas and may merge to kill large areas of the leaf in late summer. Small twig cankers may be formed.

Biology. — The fungus overwinters in the affected twigs and foliage. Spores of the fungus are spread by wind and rain-splash the next growing season.

Control. — Collect and dispose of fallen leaves. Remove unneeded branches to increase air movement. Fertilize to increase vigor and use fungicide sprays.

Figure 69. — Actinopelte leaf spots, including close-up view.

LEAF RUST: FUSIFORM RUST and EASTERN GALL RUST, *Cronartium fusiforme quercuum* (Berk) Miyabe Hedge & Long and *C.*

Importance. — In forest stands these diseases are of minor importance on oak (alternate host). However, they affect the aesthetic value of shade trees and ornamentals. Fusiform rust on pine (primary host) is the most important disease of pine in the Southeast.

Identifying the Fungi (figure 70). — Both fungi develop brown, bristly spine-like structures on the underside of the oak leaf.

Identifying the Injury. — Small yellow spots develop on the leaf surfaces in spring. Some defoliation may occur. Red, water and willow oaks are primarily affected. White oaks are seldom affected.

Biology. — Leaf rusts require two hosts to complete their life cycle. Fungus spores (aeciospores) produced on pine galls are windblown and infect young oak leaves. Spores (urediospores) are produced on the oak leaf which reinfect oak. Spiny-like hairs (telial columns) on the lower oak leaf surface release teliospores which produce another spore stage (basidiospore) that infects pine. This infection results in a gall with aeciospores, and the cycle is completed.

Control. — No control needed.

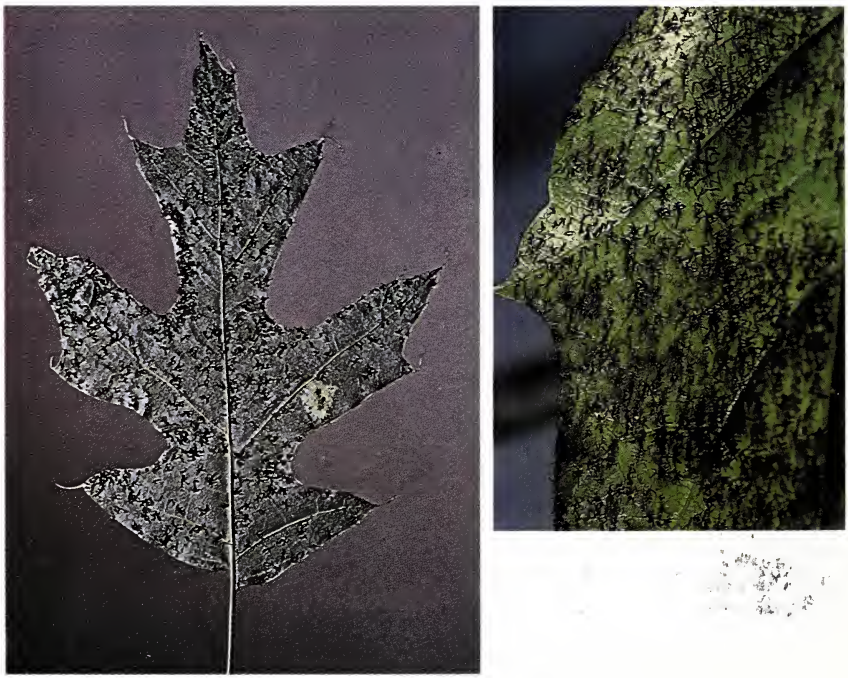


Figure 70. — Rust telial columns on oak leaf, including close-up view.

SEEDLING DISEASES

DAMPING-OFF, *Cylindrocladium* spp.

Importance. — Soil-inhabiting fungi such as *Fusarium, Cylindrocladium, Rhizoctonia, Pythium* and *Phytophthora* species cause heavy losses (25 to 50 percent) in pre- and post-emergence seedlings. Fungi attack the young developing radicles killing seedlings 30 to 45 days after the seedlings emerge.

Identifying the Fungus. — The pathogens involved are minute and can be identified only by the use of a microscope. Tentative identification can be made by cultural characteristics. *Cylindrocladium* spp. are the most important pathogens in hardwood nurseries.

Identifying the Injury (figure 71). — The first symptom is failure of seedling emergence. The seed may rot or seeds may have a dead or damaged radicle (pre-emergence damping-off). Seedlings may remain stunted (post-emergence damping-off).

Biology. — The fungi are mostly soilborne and remain inactive in the absence of a host as chlamydospores or sclerotia. The presence of host roots stimulates the fungus, which grows over roots and penetrates the epidermis and cortex. *Cylindrocladium* spp. also produce airborne conidia which may cause leaf spots and defoliation.

Control. — Grass cover crops will reduce the inoculum potential; however, clover and other leguminous cover crops increase the pathogen. Do not apply nitrogen fertilizer until 45 days after the seedlings emerge.

Figure 71. — Damping-off of oak seedlings.

PHANEROGAMS

MISTLETOE, *Phoradendron* spp.

Importance. — Branches beyond the mistletoe infection may be stunted and even die. Trees usually are not killed. However, in heavy infections on water oak, trees may decline and be killed. This true mistletoe is used for Christmas greens.

Identifying the Causal Organism (figure 72). — Leafy, evergreen tufts of perennial shoots with dark green, leathery leaves occur as bunches on branches of oaks. The plant is opposite-leaved and the stems are rounded and jointed. The flowers are inconspicous. White to red berries are produced in the fall.

Identifying the Injury. — The most conspicuous sign of the disease is the presence of the parasite. The affected branch may be slightly enlarged and multiple infections may result in tree decline. Excess shading of tree leaves by large mistletoe plants produces dieback and decline.

Biology. — The sticky seeds are spread by birds and animals. The seeds lodge on young branches, germinate, grow into the young branch and produce a mistletoe plant.

Control. — Control is normally not needed but mistletoe can be controlled by removing it and cutting branches at least 1 foot below the infection point.

Figure 72. — Mistletoe infection, including close-up view.

CHEMICAL DAMAGE, AIR POLLUTION, PESTICIDES AND OTHER CHEMICALS

Importance. — The total impact of chemical damage is unknown. Large losses have occurred in very localized areas. The losses normally can be traced to a point source such as a chemical spill or industrial waste. Not as easily recognized but perhaps more damaging are the non-point source pollutants such as those associated with a large city. Many oak species decline, dieback and succumb over a period of years. On the other hand, some oak species are relatively resistant to many pollutants and are not affected.

Identifying the Causal Agent. — Chemicals can arrive at the tree in a variety of forms through the air or soil. Several conditions must occur to cause damage. There must be a susceptible host in a receptive condition, and the chemical must arrive in a quantity and form that will affect the host. Some chemicals damage on contact, others interact with tree processes.

Identifying the Injury (figure 73). — Most chemicals have certain characteristic symptoms. *Ozone* causes small bleached or pigmented spots on the upper leaf surface. *Sulfur dioxide* kills some areas between the leaf veins. *Fluoride* kills tissue on the leaf margin or between the veins. *Ammonia* causes faded leaf margins and dead or dying tissue with green islands mostly near veins. *Herbicides* cause blotchy dead areas on the surface of mature leaves; expanding leaves curl and become distorted.

Because of great variation of susceptibility among trees and the combination of chemical and climatic factors, diagnosis is complex. Thus, proper diagnosis may require a person with extensive training and experience.

Control. — Protect from chemicals or plant resistant trees.

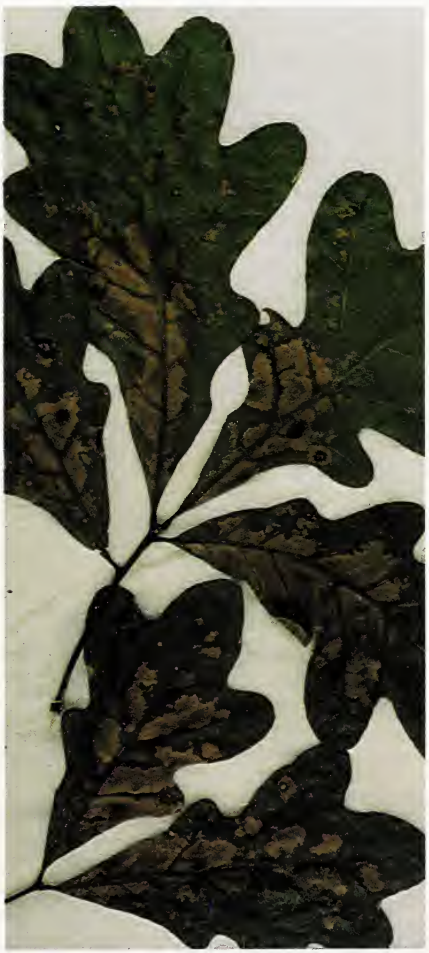


Figure 73. — Chemical damage — due to ammonia.

MINOR DISEASES

Disease Agent	Injury	Control*
Leaf spot, *Septoria* spp. The fungus overwinters on dead leaves; spores are wind disseminated to young leaves in the spring.	Small round spots with straw-colored centers may be numerous; (figure 74); red oaks are preferred; defoliation may result in growth loss, but no mortality.	4 5 14 15
Powdery mildew, *Microsphaera alni* and *Phllactinia guttata.* These fungi overwinter on dead leaves and their spores are spread by the wind to healthy leaves.	White, powdery mold patches on leaves and buds (figure 75); leaves may be distorted, stunted and dropped prematurely.	5 15
Twig canker, *Dothiorella quercina.* The fungi overwinter on dead tissues; in the spring, spores are wind disseminated to wounds and twigs.	Small sunken branch cankers and twig dieback (figure 76).	8 14 15
Spot anthracnose, *Elsinoe, quercus – falcatae.* The southern red oak is preferred host; spreads by wind disseminated spores.	Very small spots on leaf upper surface starting about mid-summer.	5 15
Smooth patch, *Aleurodiscus oakesii* (figure 77).The fungus survives on the bark surface and releases spores which continues its spread.	Often regarded as a threat to stand by owner, but it is of minor importance; control rarely needed.	
Iron-deficiency chlorosis (figure 78); iron deficiency may be a common problem with pin and willow oaks in some of the less acid soils.	Yellow-green discoloration between veins; leaves may curl, turn brown along margins and between veins.	16

*See CONTROLS page 66.

Figures 74-78.— (74) Septoria leaf spot; (75) powdery mildew; (76) twig canker; (77) smooth patch; (78) iron-deficiency chlorosis.

PESTICIDES

EPA-registered chemicals for control of insects and diseases that attack oaks. (See labels for dosages and application methods.)

INSECT	INSECTICIDE
Elm spanworm	*Bacillus thuringiensis* Carbaryl
Fall cankerworm Spring canker-worm	*Bacillus thuringiensis* Carbaryl Naled Acephate
Linden looper	Methoxychlor Naled
Orangestriped oakworm Pinkstriped oakworm Spiny oakworm	Carbaryl Chlorpyrifos Methoxychlor Naled
Yellownecked caterpillar	Chlorpyrifos
Forest tent caterpillar	Carbaryl Acephate Gardona Dylox Chlorpyrifos
Gypsy moth	*Bacillus thuringiensis* Carbaryl Methoxychlor Acephate Gardona
Variable oakleaf caterpillar	Carbaryl Malathion
Slug oak sawfly	Carbaryl Pyrethrin
Oak leafroller	Carbaryl Diazinon
Oak leaftier, Solitary oak leafminer, Gregarious oak leafminer	Carbaryl Malathion Diazinon
Oak skeletonizer	Carbaryl
Insect borers	Lindane Carbon disulfide
Oak leaf aphids Giant bark aphids	Carbaryl Diazinon Malathion Acephate
Oak lacebug	Carbaryl Malathion and mixtures Lindane Methoxychlor
Periodical cicada	Carbaryl
Lecanium scales Pit scales Kermes scales Obscure scale	Carbaryl Diazinon Malathion Methoxychlor
Spider mites	Dicofol Diazinon Malathion Naled

PESTICIDES, (continued)

EPA-registered chemicals for control of insects and diseases that attack oaks. (See labels for dosages and application methods.)

FUNGI	FUNGICIDE
Powdery mildew	Benomyl Lime sulphur
Septoria leaf spot Actinopeltes *Dothiorella quercina*	Ferbam Captan Benomyl
Elsinoe falcatae Anthracnose	Zineb Copper (metallic) Benomyl
Leaf blister	Captan Ferbam
Damping-off Clitocybe root rot Armillaria root rot	Captan Dexon
Phymatotrichum Corticium root rot *Polyporus lucidus*	
Sterum Irpex canker Poria canker Nectria canker	Lime sulphur
Botryodiplodia	Copper (metallic) plus methoxychlor
Fusiform rust *Eastern gall rust*	Captan Ferbam Oil plus lime sulphur

CONTROLS

Controls for insects and diseases presented in table form

1. Natural controls often adequate.
2. Place sticky bands around trunk.
3. Prune infected twigs and destroy.
4. Rake fallen infected leaves and destroy.
5. Maintain high tree vigor with cultural practices.
6. Open-grown trees most susceptible; maintain good stocking.
7. Identify and remove brood trees.
8. Prevent or minimize injuries.
9. Mechanically "worm-out" with knife and wire.
10. Wrap trunk of newly transplanted trees.
11. Control with chemical insecticide
12. Control with biological insecticide.
13. Control with gallery fumigation.
14. Remove and burn diseased materials from the tree and area.
15. Control with chemical fungicide.
16. Control with iron chelate.

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INDEX

INSECTS

DISEASES

INDEX, (continued)

CAUTION

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key — out of the reach of children and animals — and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, benecial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed them. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S. Department of Agriculture, consult your State forestry agency, county agricultural agent or State extension specialist to be sure the intended use is still registered.

Use Pesticides Safely

FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE